STOCK STATUS UPDATE OF UNIT 3 REDFISH FOR 2022

Context

A 10,000 metric tonnes (t) Total Allowable Catch (TAC) was implemented for Unit 3 Redfish (4X+ 4Wdehkl) in 1993 based on the 1991 TAC for the previous management unit (North Atlantic Fisheries Organization (NAFO) Subarea 4VWX), prorated by historical (1981–1990) catches in the Statistical Unit Areas which comprise Unit 3 (Atkinson and Power 1991). This TAC was maintained from 1993–1998 based on conclusions from a series of stock status reports which indicated that stock conditions were not expected to decline in coming years (Branton and Halliday 1994, Branton 1995, 1996, 1997, 1998). In 1999, the TAC was reduced to 9,450 t, followed by a reduction to 9,000 t in 2000 due to lower catch rates in 4W and a shift in fishing effort from 4W to 4X (Branton 1999). The TAC was further reduced to 8,000 t in 2022. Conservation measures for Unit 3 Redfish currently include protocols for protecting small fish below the minimum size of 22 cm fork length (FL) (i.e., closure areas, small fish amounts not to exceed 15% of catch/trip), 100% dockside monitoring and electronic vessel monitoring (VMS), mandatory hail out and hail in, and a target level of 10–20% at-sea observer coverage.

Information on the status of Unit 3 Redfish (i.e., distribution, abundance, biomass) from 1999–2002 was provided through a series of Canadian Science Advisory Secretariat (CSAS) Research Documents that included a synopsis of the Fisheries and Oceans Canada (DFO) Summer Research Vessel (RV) Survey trends back to 1970 for selected groundfish stocks (e.g., Branton and Black 2002). Since 2009, the status of Unit 3 Redfish has been updated through a series of CSAS Science Responses (e.g., DFO 2017a), based on RV survey trends in biomass and abundance. Following the development of biological reference points consistent with the precautionary approach (DFO 2012), the DFO Summer RV Survey Trends Science Responses from 2014 to 2019 have included plots of the mature biomass index for redfish > 22 cm FL relative to the Upper Stock Reference (USR; 80% of Biomass at Maximum Sustainable Yield [B_{msy}] proxy) and the Limit Reference Point (LRP; 40% of B_{msy} proxy) (DFO 2020). In 2015, a zonal peer review of the assessment framework for Units 1–3 Redfish (DFO 2017b) included a detailed review of Unit 3 Redfish stock status; however, this information has not yet been published, and as a result, there has been no new information available on the fishery for several years.

In 2018, DFO Resource Management asked Science to review biological and fishery information on Unit 3 Redfish, to evaluate the status of the stock relative to adopted reference points (DFO 2012), and report on bycatch of non-target species in the Unit 3 Redfish Fishery (DFO 2019). A science response was provided in 2020 (DFO 2021) but not in 2021 as no new RV survey data were available This science response provides a stock status update of Unit 3 Redfish using the most up to date landings and RV survey data.

This Science Response Report results from the regional peer review of December 6–7, 2022, on the Update of Stock Status for Unit 3 Redfish.

Background

Biology

Redfish, known commercially as Ocean Perch, occur on both sides of the Atlantic Ocean. They are found along the slopes of fishing banks, in deep channels, and off the edge of the continental shelf at depths ranging from 100–700 m. In the northwest Atlantic, redfish range from Baffin Island in the north to the coast of New Jersey in the south. Two species of redfish are found on the Scotian Shelf: Acadian Redfish (*Sebastes fasciatus*), which occur in the deep basins and at the edge of the continental shelf, and Deepwater Redfish (*Sebastes mentella*), which occur in deeper waters off the continental shelf and in the Laurentian Channel. These two species are difficult to distinguish visually and as a result, they are not separated in either the commercial or research survey catches.

Redfish are ovoviviparous as fertilization is internal and young are born live. Mating occurs in the fall (September–December) and females carry the developing young until release during spring and early summer (April–July). Larvae develop in surface waters and move to deeper waters as development progresses. Redfish are sexually dimorphic with females growing faster than males after age 10. The average length at which 50% of redfish on Scotian Shelf are mature is 24–26 cm FL for females and 16–17 cm FL for males. They are slow growing (8–10 years to reach a size of 25 cm FL), long-lived, and characterized by a late age of sexual maturation (7–9 years to reach sexual maturity). This means that they are sensitive to overfishing and slow to recover from depletion (as evidenced by northern stocks). Recruitment success varies significantly, with long periods of low recruitment coupled with sporadic occurrences of strong year classes occurring at unpredictable and irregular intervals. Redfish are semi-pelagic and exhibit diel movement patterns rising off bottom at night to feed. Food consists primarily of pelagic crustaceans such as amphipods, copepods and euphausiids; fish become an important part of the diet as redfish increase in size.

Description of the Fishery

Redfish on the Scotian Shelf were historically managed as a NAFO Division 4VWX stock. In response to a new understanding of stock structure (Atkinson and Power 1991), a new management area for Unit 3 Redfish was implemented in the 1993 Groundfish Management Plan and consists of Statistical Unit Areas 4X and 4Wdehkl (Figure 1). Genetic research has shown that redfish in Unit 3 are almost exclusively S. *faciatus* and belong to a separate stock from S. *faciatus* in Unit 1 (Gulf of St. Lawrence/northern Laurentian Channel) and Unit 2 (southern Laurentian Channel/Western Grand Bank) (Morin et al. 2004). Unit 3 Redfish are also considered to be separate from the Gulf of Maine/Georges Bank stock.

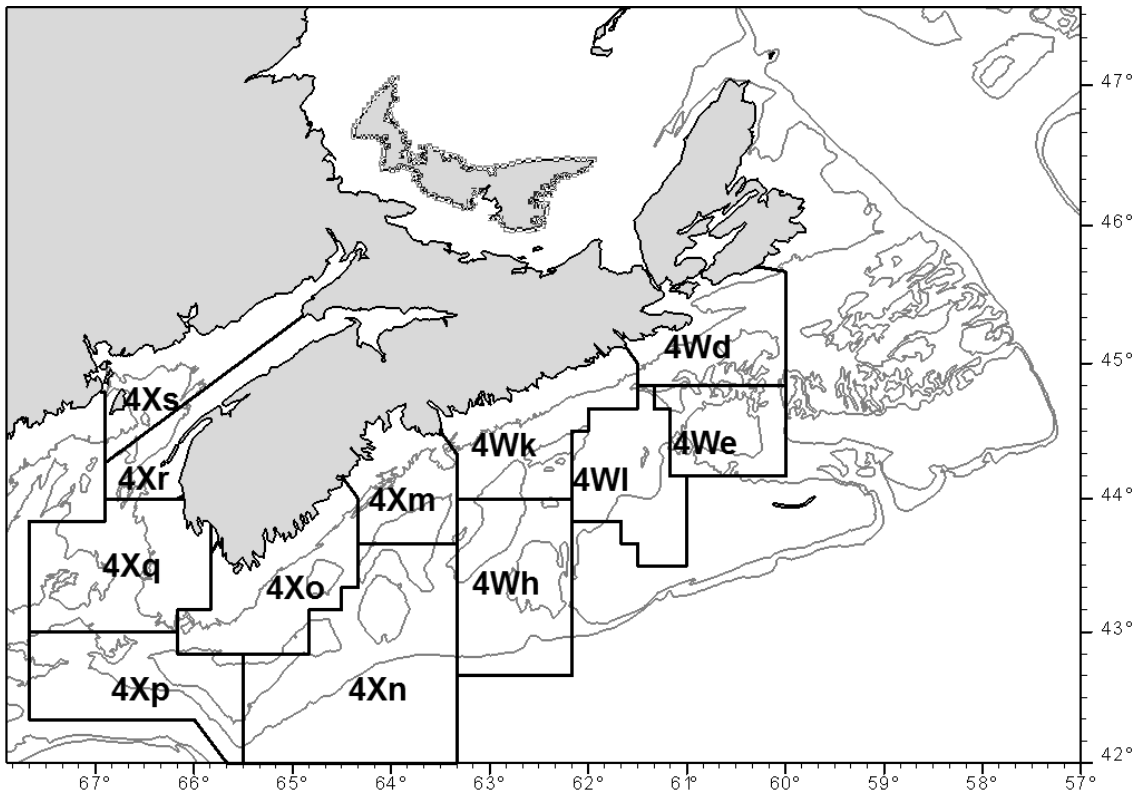

Figure 1. Unit 3 Redfish Management Area 4X+4Wdehkl.

Within the Unit 3 management area, the main geographic areas fished over the past 5 years include Crowell and Jordan basins (4Xpq), the Scotian Shelf slope (4Xn, 4Wh), the Sambro Bank area (4Xm, 4Wk) and the northern edge of LaHave Basin (4Xm). In some years, fishing activity has also occurred on Browns and Baccaro banks, LaHave Bank, and in Emerald Basin. Redfish is fished primarily using bottom trawls and can be directed for with small mesh cod ends (110–115 mm diamond mesh) and are sold as fillets or used for lobster bait.

Two areas in 4X have been closed to small mesh gear due to persistent catches of undersized redfish, one in 4Xo (“Bowtie Closure”, implemented in 1995) and the other in 4Xmn (“Second Closure”, implemented in 2013). Redfish ≤ 22 cm FL are considered immature and there are restrictions on the proportion of these small fish in the landed catch per trip (i.e., no more than 15%).

Total landings of Unit 3 Redfish reached 18,000 t in the early 1970s when foreign fleets (mostly from the USA) fished on the Scotian Shelf (Table 1, Figure 2). Catches by foreign fleets declined after implementation of the 200 mile limit in 1977 and dropped off entirely by the early 1990s. Canadian landings have averaged around 4,000 t since 1970, peaking at 9,000 t in 1974 and more recently at 8,000 t in 2012. During the 1970s, landings were dominated by catches in 4W, but after 1980 they shifted to 4X which has accounted for about 87% of landings from 1980 to 2022 and 83% and 78% of landings in 2021 and 2022, respectively. Within 4X, there was a shift in landings from 4Xmno to 4Xpq in the late 1990s, probably to reduce capture of small fish. The TAC has been 9,000 t since 2000 but reduced to 8,000 t in 2022. Landings have not exceeded this amount and were 4,886 t in 2021 and as of November 14th, 2022 are at 2,143 t. Between 2012 and 2021, quarter 2 (April–June) accounts for most landings (54%), followed by quarter 3 (25%), quarter 4 (13%) and quarter 1 (9%).

Table 1. Total reported Canadian and foreign landings (metric tonnes) of Unit 3 Redfish from 1970–2022. Decadal average landings are based on data up to 2019. FY = Fishing year landings (April 1–March 31). Landings for 2022 are preliminary, extracted November 14th, 2022.

	Year(s)	Canada		USA		USSR	Other	Total	TAC	FY
		4X	4Wdehkl	4X	4Wdehkl					
Decadal Average	1970–79	2,042	2,036	2,966	2,254	394	92	-	-	-
Decadal Average	1980–89	3,229	1,175	510	0	1.8	2.3	-	-	-
Decadal Average	1990–99	3,932	393	5	0	26	28	-	-	-
Decadal Average	2000–09	3,595	100	0	0	0	3	-	-	-
Decadal Average	2010–19	4,163	612	0	0	0	0	-	-	-
Annual	2013	2,914	1,108	0	0	0	0	4,022	9,000	4,240
Annual	2014	2,524	1,356	0	0	0	0	3,880	9,000	3,579
Annual	2015	2,591	593	0	0	0	0	3,184	9,000	3,516
Annual	2016	3,767	384	0	0	0	0	4,151	9,000	3,948
Annual	2017	4,198	398	0	0	0	0	4,596	9,000	4,562
Annual	2018	3,439	201	0	0	0	0	3,641	9,000	3,681
Annual	2019	4,162	219	0	0	0	0	4,381	9,000	4,314
Annual	2020	3,162	88	0	0	0	0	3,250	9,000	3,537
Annual	2021	4,146	839	0	0	0	0	4,986	9,000	4,835
Annual	2022	1,680	462	0	0	0	0	2,143	8,000	1,843

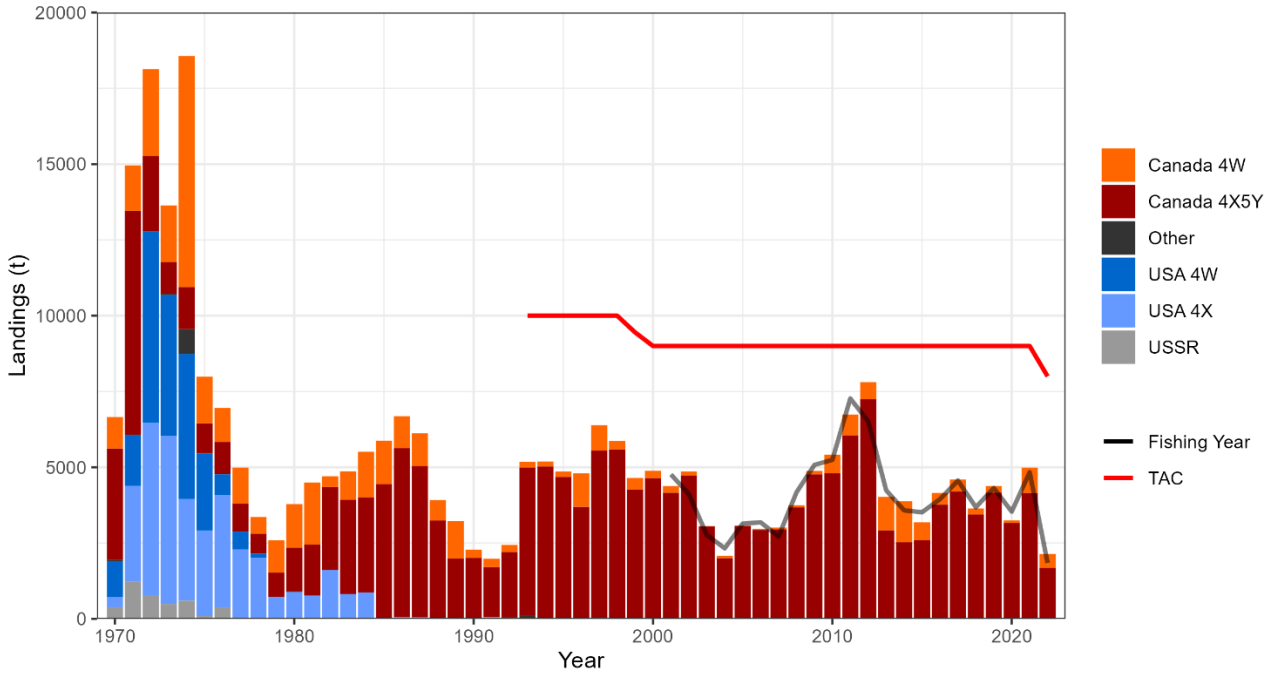

Figure 2. Unit 3 (4X+4Wdehkl) Redfish landings (metric tonnes) from 1970–2022 (histograms = Calendar Year; black line = Fishing Year). The red line is the Canadian Total Allowable Catch (TAC) for the fishing year. Landings for 2022 are preliminary.

Assessment Framework

While no formal modelling approach has been developed to determine stock status, empirically determined reference points have been calculated for Unit 3 Redfish using DFO Summer RV

Survey data for mature biomass (> 22 cm FL) (DFO 2012). A proxy for B_{msy} (73,000 t) was calculated as the survey mean mature biomass from 1970–2010. Forty percent of the B_{msy} proxy was presented as the LRP (29,000 t) and 80% as the USR (58,000 t). The mature biomass index from the DFO Summer RV Survey (smoothed using a 5-year arithmetic moving average), is used to determine current stock biomass in relation to biological reference points.

Analysis and Response

DFO Summer Research Vessel Survey

A stratified-random bottom trawl survey of the Scotian Shelf/Bay of Fundy has been conducted in July and August since 1970 and has provided coverage of the entire Unit 3 stock area (defined as strata 456, 458–495 in Branton and Halliday 1994). Due to vessel issues, full coverage of Unit 3 strata was not achieved in 2018 and 2022. No survey biomass was calculated for 2021 due to a change in vessel and the inconsistency this could introduce. These data will be available in future years when conversion factors are available.

Not all strata in NAFO Division 4W were sampled during the 2022 DFO Summer RV Survey; therefore, the biomass index time-series was recalculated using only the strata covered in the 2022 survey (460–495). Since most of the Unit 3 Redfish biomass occurs in the NAFO Division 4X (Strata 470–495), the trajectories for total and mature biomass indices are very similar for all of the Unit 3 strata compared to the strata sampled in 2022 and strata sampling in 2018 (Figure 3). As a result, all Unit 3 Redfish strata (456, 458–495) were used to calculate the 1970–2022 biomass index. This is the same approach that was used when all strata were not covered in the 2018 survey (DFO 2019).

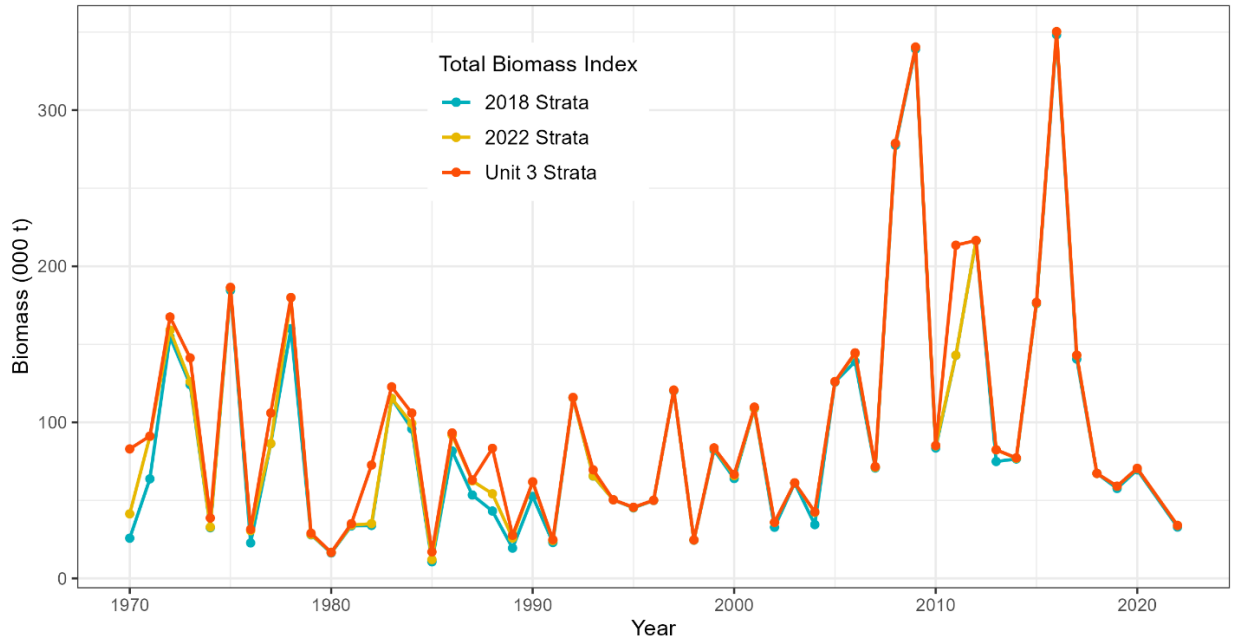

Figure 3. DFO summer survey total biomass (t x 10^3) for three assemblages of a) Unit 3 Redfish Strata as defined by Branton and Halliday (456, 458–495, orange), b) strata covered in 2018 (460, 461, 465, 470–495, blue), and c) strata covered in 2022 (460–495, yellow). No survey biomass is available for 2021.

Mature redfish biomass was calculated using stratified total abundance at size (for lengths > 22 cm FL) and the length-weight relationship for combined sexes calculated using length and weight data from 1992–2019.

Total and mature biomass were variable from the late 1970s to the early 1990s with the 5-year average based on mature biomass declining, remaining low but variable through to the mid-2000s, then increasing to higher levels from 2007–2016 (Figure 4). Much of the total biomass in 2008–2009 (44–55%) and 2011–2012 (36–40%) was comprised of immature fish (≤ 22 cm FL), which may indicate earlier periods of strong recruitment. Total and mature biomass has remained low since 2018, at levels comparable to the 1990s. Since no survey biomass conversion factor was available for 2021, the 5-year arithmetic mean of mature biomass for 2022 is calculated using only 4 years of survey data (2018–2020, 2022).

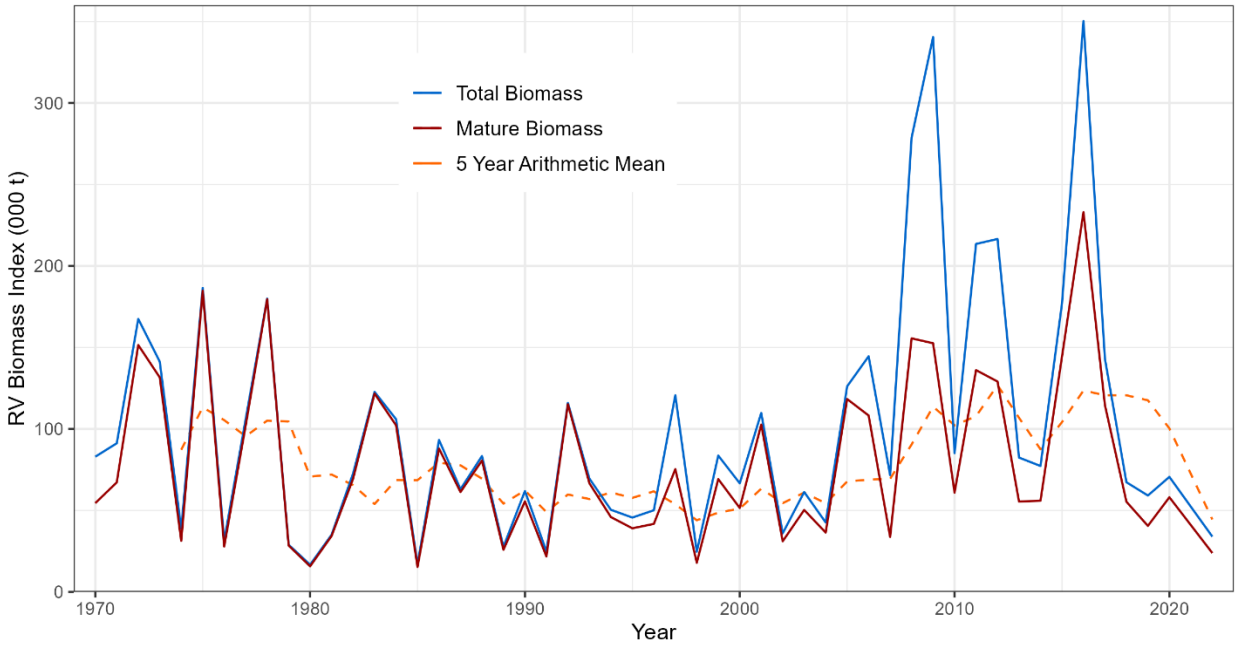

Figure 4. DFO summer survey total biomass (blue), mature (> 22 cm FL) biomass (red) and mature biomass index (5-year moving average, orange) for Unit 3 Redfish Strata (456, 458–495) from 1970–2022. The biomass indices are in tonnes x 10^3.

There was a decline in the DFO summer RV survey abundance-at-lengths from 2020 to 2022 (Figure 5). The 2020 and 2022 abundance-at-length peaked at the same length (24 cm). The short-term median abundance index (2010–2019) was higher than the long-term median abundance index (1970–2019) but peaked at a smaller size (i.e., 23 cm vs 25 cm FL), indicating higher abundance of smaller fish during the short-term period. Both 2020 and 2022 abundance-at-lengths have a second smaller peak at 8 cm and 15 cm respectively which may indicate a strong recruitment event.

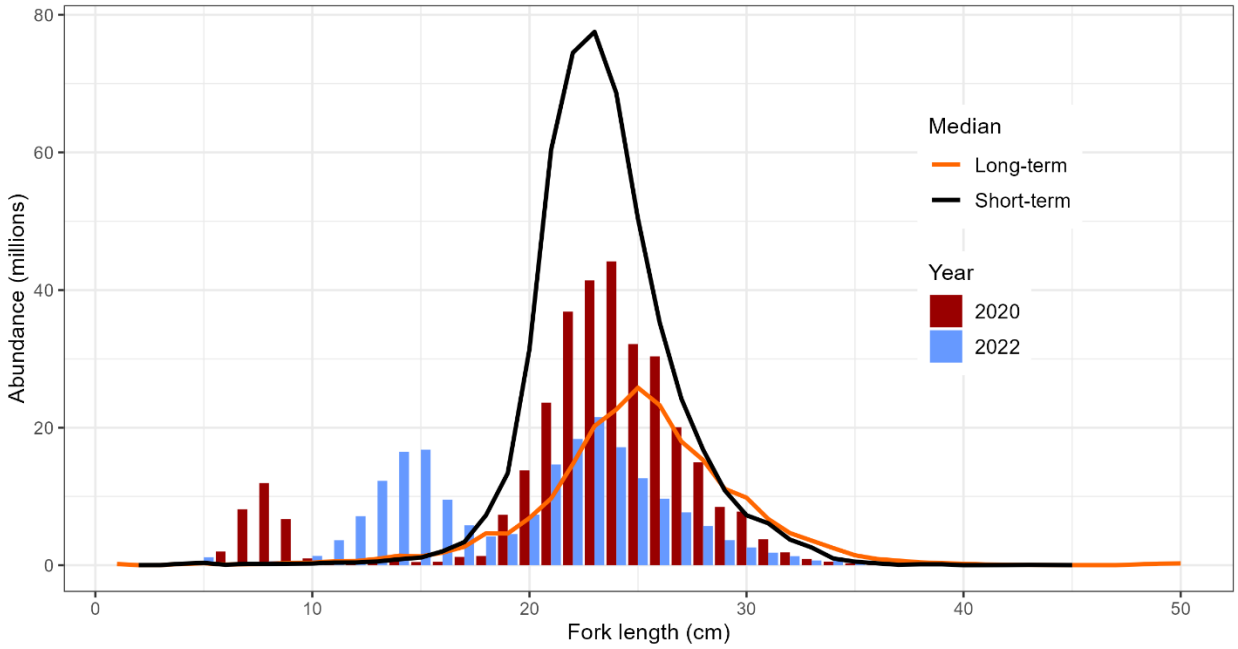

Figure 5. Length frequency indices for Unit 3 Redfish from DFO Summer Research Vessel surveys, 1970–2022. Red bars represent the numbers in millions at length from the 2020 survey; blue bars represent numbers in millions at length from the 2022 survey. Note: no RV survey data are available for 2021. The orange line represents the long term median abundance-at-length (1970–2019) and the black line is the short-term median abundance-at-length (2010–2019).

Condition

Condition factor was calculated separately for males 23–40 cm FL and females 23–45 cm FL using Fulton's *K* (weight/length^3). During the 1970s and 1980s, *K* was higher for both sexes, but because spring balances were used during this period, these data may be less precise. (Figure 6). For 1992–2022 (the time period for electronic balances), *K* has generally hovered around the 1992–2022 average for males and shown no consistent directional change. For females, *K* has shown a declining trend since 2009 and remains below the 1992–2022 average. The reason for this is unclear, but warmer water temperatures in recent years may result in more spawning before the survey takes place. Similar declines in condition have been observed for other Scotian Shelf species such as Silver Hake (Stone et al. 2013), Pollock (Stone 2010) and Haddock (Stone and Hanson 2014).

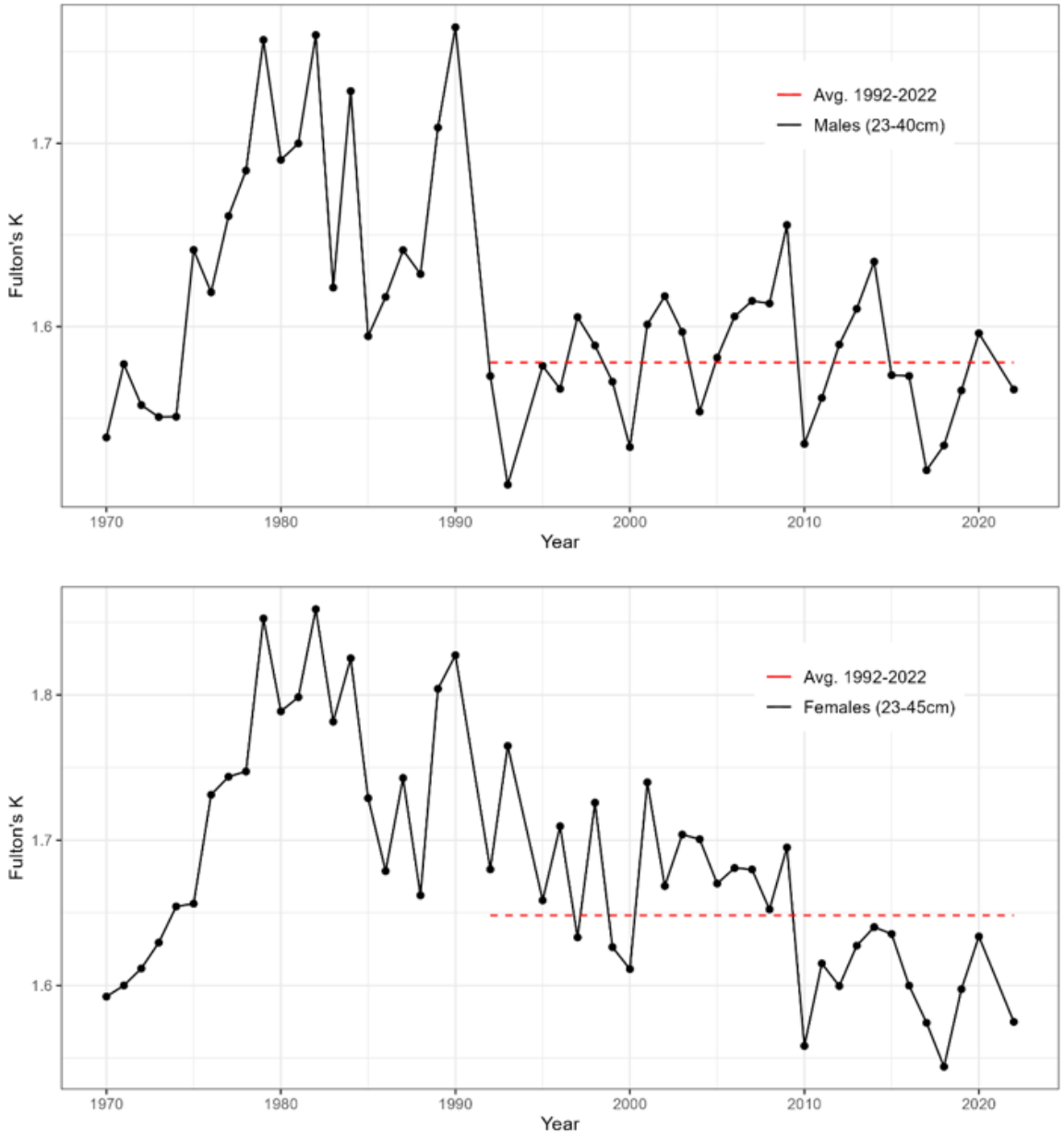

Figure 6. Fulton's condition factor (weight(g)/length(cm)^3) for male (23–40 cm FL; upper panel) and female (23–45 cm FL; lower panel) redfish from DFO Summer RV Survey length and weight data for 1970–2022.

Fishery Average Size and Percent ≤ 22 cm Fork Length

The average size of redfish (weighted mean length calculated from the fishery catch-at-size) declined from the mid-1970s to the late 2000s but has been increasing since 2011 and has remained stable in recent years (Figure 7). The percentage of small fish in the catch exceeded the 15% tolerance level from 1990–2002 and more recently from 2007–2014 but has remained below that tolerance level since then. Implementation of the "Second Closure" area (4Xmn) in 2013 may have helped to reduce the catch of small redfish (≤ 22 cm FL) in recent years leading to an increase in average size since 2011 along with growth of cohorts in the fishery.

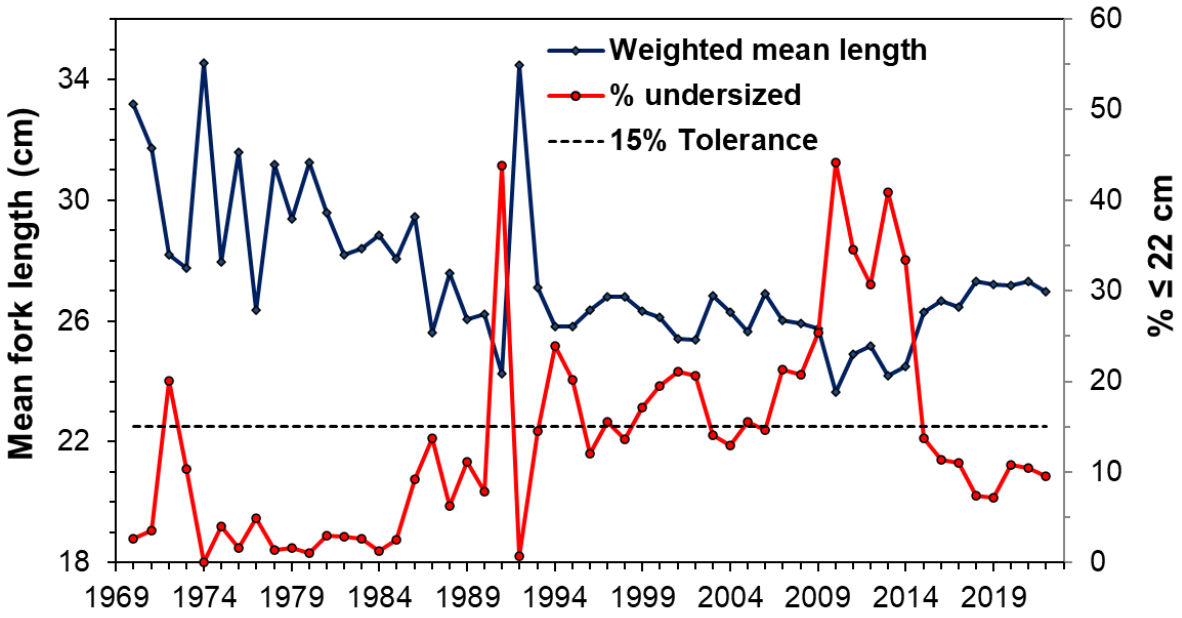

Figure 7. Mean fork length (cm) of redfish from the commercial fishery catch-at-size (blue) and percentage of catch-at-size ≤ 22 cm FL (red) for 1970–2022. The dashed black line indicates the 15% tolerance level.

Reported Landings of Redfish and Bycatch Species

The 4X component of the Unit 3 management unit has more mixed species bycatch landings than 4W, so bycatch landings are presented separately for both areas (Figure 8). Bycatch landings for 2013–2022 from the MARFIS commercial landings database averaged 27% of total landed catch in the 4X fishery compared to 11% in 4W. For 2013–2022, the most common landed bycatch species in 4X is Pollock (11%), followed by Haddock (9%), White Hake (3%), and Atlantic Cod (1%). Pollock is also the main bycatch in 4Wdehkl but at a lower level (3%), followed by Monkfish (2%), non-specified skates (2%), and White Hake (1%).

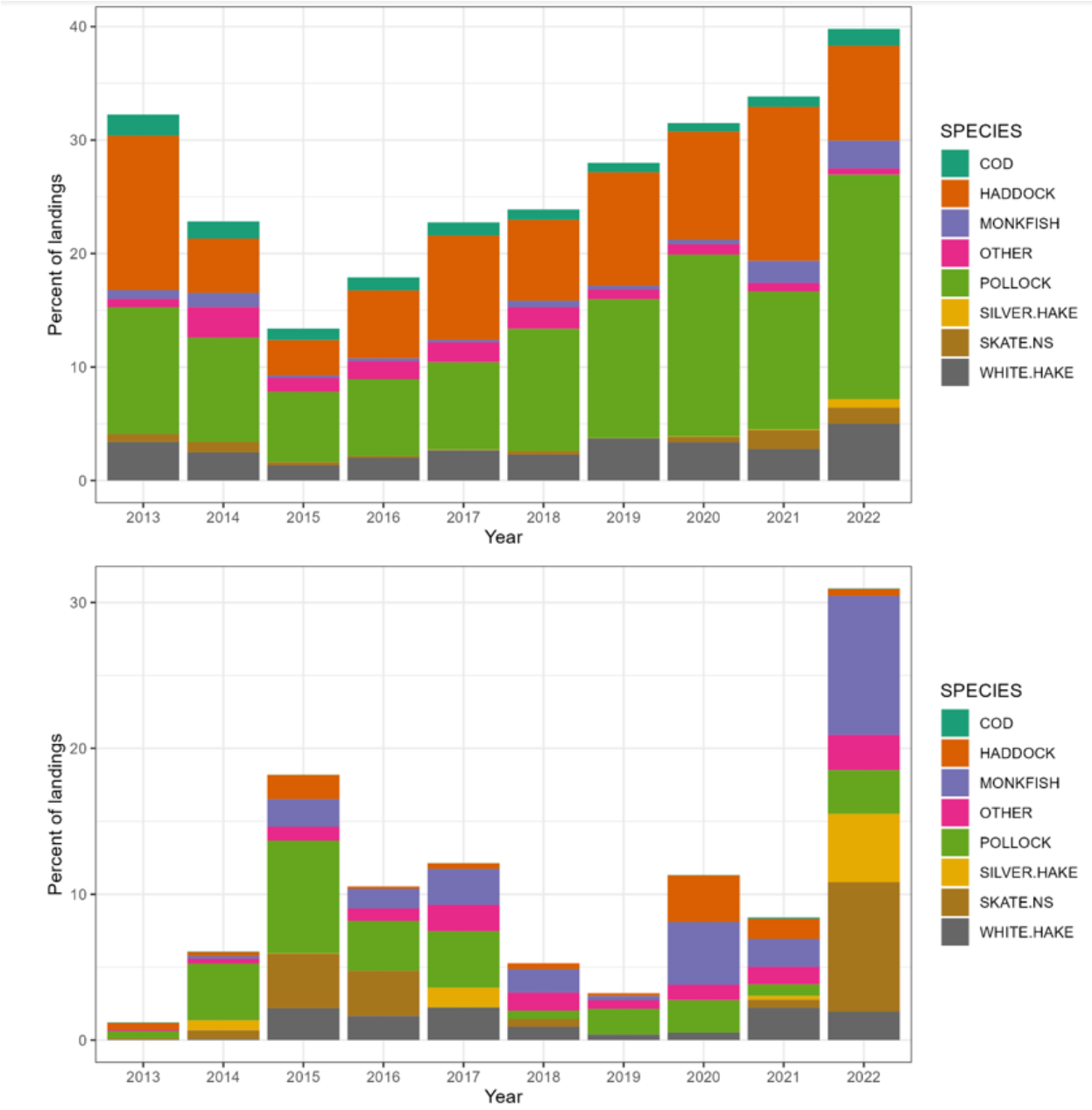

Figure 8. Percentage of landings by bycatch species from the Unit 3 Redfish fisheries in 4X (upper panel) and 4Wdehkl (lower panel), 2013–2022.

Observer Coverage and Bycatch

Estimates of at-sea observer coverage levels for the redfish fishery use data from the Observer Program Database and the Maritimes Fishery Information System (MARFIS) Commercial Landings Database for mobile gear with 110–115 mm diamond mesh cod ends (81% of total redfish landings in 2021). On average, about 7% of redfish landings and trips have been observed over the past 5 years (Table 2). With the exception of 2018, coverage has been below the 10–20% target level proposed by Resource Management.

Table 2. Percent observer coverage (observed redfish catch/total redfish landings; observed redfish trips/total redfish trips) for the directed mobile gear redfish fishery in Unit 3, 2018–2022.

Year	Total Landings (t)	Total Trips	Observed Catch (t)	Observed Trips	Observed Landings (%)	Observed Trips (%)
2018	2,962	144	293	17	9.9	11.8
2019	3,403	181	299	16	8.8	8.8
2020	2,638	155	99	7	3.8	4.5
2021	4,050	232	284	14	7.0	6.0
2022	1,546	122	40	3	2.6	2.5
Avg (2018–2022)					**6.4**	**6.7**

Observer data from 2003–2022 (241 trips in 4X and 86 trips in 4Wdehkl) indicate that 91% and 94% of the total observed catch (kept + discarded) from Unit 3 Redfish trips is retained in 4X and 4Wehkl, respectively. At-sea observers recorded similar proportions of retained bycatch as reported in the commercial landings database. Redfish (71%), Pollock (14%), Haddock (8%), and White Hake (2%) are reported as the main species retained in 4X compared to redfish (84%), Pollock (11%), and White Hake (1%) in 4Wdehkl. Total discard amounts are low and represent 9% of observed catches in 4X and 6% in 4Wdehkl for 2003–2022. Discarded species in 4X include Spiny Dogfish (6%) and American Lobster (1%) and in 4Wdehkl include Spiny Dogfish (2%) and Barndoor Skate (1%).

Harvest Control Rule

The smoothed (5-year moving average) mature biomass index from the DFO Summer RV Survey is used to determine the current stock biomass in relation to biological reference points. Management Strategies for Unit 3 Redfish outlined in the 2017 Groundfish Integrated Fishery Management Plan (IFMP) for the Maritimes Region indicate that a TAC may be set to achieve a maximum 9% exploitation rate based on the index when it is above the USR. When the index is below the USR, the TAC may be set to achieve a maximum 6% exploitation rate; however, it is required that the exploitation rate will decline as the stock progresses lower into the Cautious Zone. When mature biomass is below the LRP, the TAC is reduced so that the exploitation rate does not exceed 3% of the index. When the stock is above B_{MSY}, a moderate increase may be considered, not to exceed 12%. The smoothed biomass index has never fallen below the LRP. The stock had been above the USR (58,000 t) from 2004 to 2020 but the index fell to 44,467t in 2022 which is below the USR (Figure 9). The realized exploitation rate based on the index in 2022 was 4.8%.

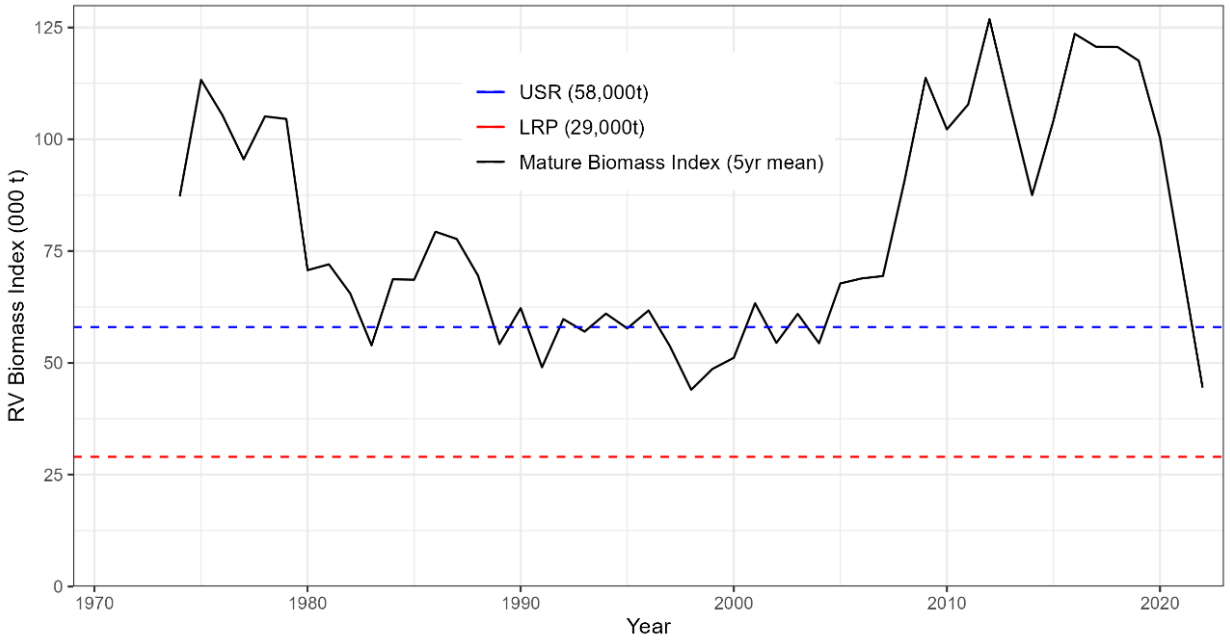

Figure 9. Mature biomass index (5-year smoothed moving average) calculated for Unit 3 Redfish strata (456, 458–495; 1970–2022). Dashed blue line = Upper Stock Reference (58,000 t). Dashed red line = Limit Reference Point (28,000 t).

Relative Fishing Mortality

A target Removal Reference (RR = 0.068) was proposed based on the maximum Relative Fishing Mortality (Relative F) that would not result in a reduction in population biomass. This value, also known as the replacement ratio, was determined using an “index based” assessment methodology (NEFSC 2002) using a centred 3-year smoothed moving average for the DFO Summer RV Survey mature biomass index based on data for 1970–2010 (DFO 2012).

Relative F is calculated as Fishery Landings/DFO Summer RV Survey mature biomass index (smoothed with 3-year moving average) (Figure 10). The highest values occurred in early 1970s, mid-1980s and late 1990s when landings were high relative to the mature biomass index. Relative F has been at or below the proposed 1970–2010 RR (0.068) from 2003 to 2020. Relative F was estimated at 0.122 in 2021 and 0.094 in 2022 which is above the RR. Due the absence of 2021 survey data, Relative F for 2020–2022 was calculated using reduced data so caution should be taken when interpreting the results. Landings have remained fairly consistent during this timeframe so the increase in the relative estimate is due to the decline in surveyed mature biomass.

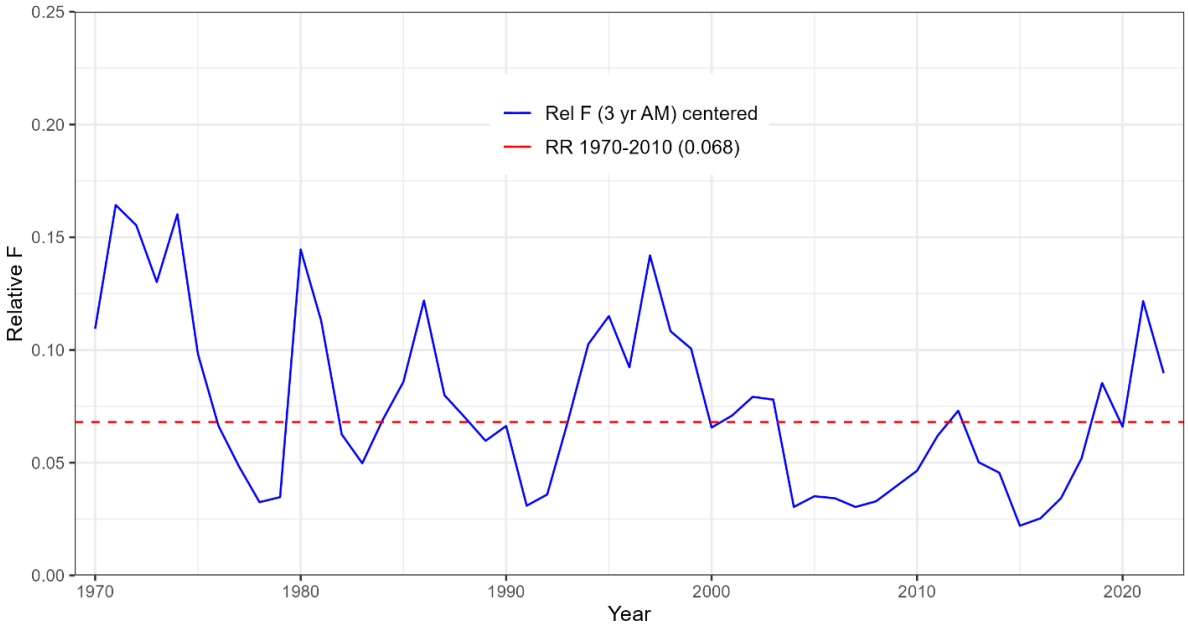

Figure 10. Relative Fishing Mortality (Fishery Landings/Survey Mature Biomass Index with 3-year centred arithmetic mean smoother; blue line) for Unit 3 Redfish, 1970–2022. The proposed Removal Reference (RR) calculated using the index method is shown for 1970–2010 (dashed red line).

Conclusions

The total landings for Unit 3 Redfish have generally been less than half the TAC over the past 20 years. The average size of redfish in the fishery catch-at-length has been increasing since 2011 and has remained stable in recent years. Percentage of immature fish (≤ 22 cm FL) in the catch-at-length has remained less than the 15% tolerance since 2014.

The 4X component of the Unit 3 management unit is more of a mixed species fishery than 4Wdehkl with bycatch landings for 2013–2022 averaging 27% of total landed catch in 4X compared to 11% in 4Wdehkl. Pollock is the most commonly landed bycatch species in both areas.

About 6% of redfish landings and trips have been observed over the past 5 years with observers recording similar proportions of retained bycatch as reported in the commercial landings database. Discard amounts are low and estimated to be 9% of total observed catches in 4X and 6% in 4Wdehkl for 2003–2022. The main discarded species are Spiny Dogfish, American Lobster, and Barndoor Skate, all at low levels.

The DFO summer RV survey results indicate that total and mature biomass has remained low since 2018, at levels comparable to the 1990s. The mature biomass index has never fallen below the LRP but the index fell to 44,467 t in 2022 which is below the USR (58,000 t) and in the Cautious Zone.

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